

# Homework No. 12 (Fall 2022)

## PHYS 205A-002: UNIVERSITY PHYSICS

*School of Physics and Applied Physics, Southern Illinois University–Carbondale*

Due date: Friday, 2022 Dec 9, 2:00 PM, on D2L

### Instructions

- You are encouraged to use any of the resources to complete this homework. However, the extent to which you depend on resources while doing this homework is a measure of how much extra work you need to put in to master the associated concepts. Solutions should be the last resource and are available at

<http://sphics.com/tc/202101-SIU-P205A/>.

- Describe your thought process in detail and organize it clearly. Make sure your answer has units and the right number of significant digits.
- After completion, scan the pages as a single PDF file, and submit the file on D2L (under Assessments → Assignments).

### Problems

1. **(10 points.)** Three identical stars, each of mass  $m$ , are positioned at the corners of a square of edge length  $L$ .
  - (a) Find the magnitude and direction of the gravitational field at the vacant corner of the square due to the three stars.
  - (b) Find the magnitude and direction of the gravitational force a planet of mass  $M$  would experience if it is placed in the vacant corner.
  - (c) Find the magnitude and direction of the gravitational field at the center of the square.
2. **(10 points.)** Determine the expression for the gravitational field at point  $\mathcal{O}$  in Figure 1, along the bisector of the line segment connecting two identical stars, masses  $m_1 = m_2 = m$ , that are separated by distance  $2a$ .
3. **(10 points.)** Four identical stars, each of mass  $m$ , are positioned at the corners of a square of edge length  $L$ .
  - (a) Find the gravitational potential at a distance very far away from the square, that is, at infinity.

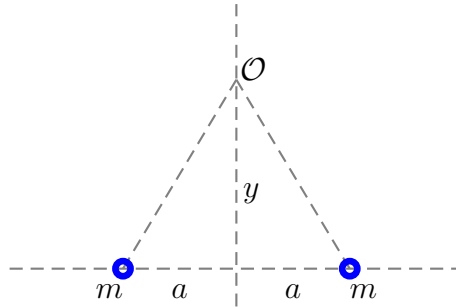


Figure 1: Problem 2

- (b) Find the gravitational potential at the center of the square.
- (c) Find the gravitational potential at the center of one of the edges of the square.
- (d) How much work is done by the gravitational forces when a mass  $M$  is moved from infinity to the center of the square?

Refer Errata on course webpage for errors in the solution for Problem 3d. There, search for 2021 Spring, HW-12.

- 4. (10 points.) Three identical stars, of mass  $m$  each, are positioned at the corners of an equilateral triangle of edge length  $a$ . Find the expression for the gravitational potential energy of this three-body configuration up to a constant.
- 5. (10 points.) At the surface of Earth a rocket is launched in the radially outward direction with a speed equal to the orbital speed of the International Space Station ( $\sim 7.7$  km/s). Neglecting the gravitational influence of the Sun and other planets, and air resistance, determine how far the rocket would go. Compare this distance to the Earth-Moon distance. Next, derive the escape velocity of Earth.